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Characteristics of Five Climax Stands in New Hampshire

W. B. Leak

Abstract

Analysis of species composition, stand density, and diameter distribution in five climax or old-growth stands in New Hampshire indicates that the northern hardwood climax is characterized by at least 65 to 70 percent tolerant hardwoods, 130 square feet basal area per acre, and "q" ratios (2-inch diameter classes) of 1.3 to 1.4. Climax spruce-hemlock have at least 70 percent tolerant softwoods, 180 to 200 square feet basal area per acre, and "q's" of 1.5 to 1.6.

In the summer of 1984, prism-plot surveys were made of several old, undisturbed stands in New Hampshire. The purpose was to define the characteristics of climax hardwood and softwood stands to use as baseline information for ecological studies and for refining uneven-age management guidelines. A recent survey of old-growth stands in New Hampshire provided in-depth descriptions of species, structure, dead material, and herbaceous cover (Carbonneau 1986a, b). In this paper, I discuss species composition, diameter distribution (including tree size), and basal area per acre. This information should help foresters decide if a stand is approaching the climax condition.

The term "climax," "old-growth," and "virgin" forest are used in different ways. In this study, the objective was to define the characteristics of stands that had attained or were approaching a steady-state condition, the point where species composition and diameter distribution remain essentially constant over long periods of time (a few hundred years).

WILLIAM B. LEAK is a research forester, Northeastern Forest Experiment Station, Durham, New Hampshire.

Areas

The five New Hampshire study areas are characterized briefly in Table 1. All of the areas supported typical uneven-aged forests containing mixtures of different size trees; distrinct even-aged stands were not evident. The Bowl is a well-known virgin forest on the White Mountain National Forest designated as a Research Natural Area. The northern hardwood stand included in this study is a ± 50-acre tract bordered by the Wiggins Trail and Wonalancet Brook (Leak 1973 and 1974, Martin 1977). Mountain Pond North is a stand of northern hardwoods approximately 100 to 150 acres in size located in the Saco District, White Mountain National Forest. The Williams Tract is an old stand of northern hardwoods in Stoddard, New Hampshire, that is owned by the Society for the Protection of New Hampshire Forests. Possibly, the area received some light cutting (for softwoods probably) some years back, or experienced some windthrow from the 1938 hurricane or earlier storms. The area examined in this study was a 20- to 30-acre stand on the eastern side of the tract. Bartlett Ridge and Bartlett 19 are small areas of softwood (20 acres ±) on the Bartlett Experimental Forest, New Hampshire, that were not cut, or very lightly cut, during the logging for softwoods about 1900 or before. These softwood stands contain many large, old trees, but not many snags or logs. Thus, these softwood stands are best described as overmature stands that have not quite reached the climax or old-growth condition; basal areas quite possibly are higher in these stands than in older stands that have begun to experience mortality and blowdown.

Methods

Prism plots were located systematically on a 3 to 5 chain square spacing depending upon the size of the stand. Trees larger than 5.0 inches d.b.h. were sampled with a 10-factor prism, while those in the 2- and 4- inch classes were sampled with a 5-factor prism.

Table 1.—Characteristics of the five study areas

Area	No. plots	Approximate elevation	Predominant[a] habitats	Cover type
		Feet		
Bowl	26	2,000	Fine Till	Beech-birch-maple
Mt. Pond North	15	2,100	Fine Till	Beech-birch-maple
Williams Tract	20	1,500	Fine Till	Beech-birch-maple
Bartlett Ridge	18	1,500	Washed Till, Bedrock	Hemlock/Red Spruce
Bartlett 19	14	1,000	Silty Sediments	Hemlock/Red Spruce

[a] Leak 1982.

Results

Species

Species composition of the Bowl and Mountain Pond North were 68 percent (by basal area) or more beech and sugar maple, the two common climax species on fine till soils in the region (Table 2). Nearly 80 percent of Mountain Pond North was composed of these species; apparently, this stand is close to the maximum proportion of tolerant species attainable. In contrast, the Williams Tract contained 48 percent beech and sugar maple plus 26 percent red maple—a species that is normally associated with successional or climax stands on softwood sites. Despite the large trees, the Williams Tract shows evidence of some cutting history, probably for softwoods, or blowdown.

Bartlett Ridge and Bartlett 19 contain 70 to 75 percent tolerant, climax softwoods. Red maple, yellow birch, and beech are the common hardwood associates. At these elevations, hemlock is more aggressive and abundant that red spruce. At elevations of about 1,800 to 2,000 feet or more, spruce becomes the more aggressive species.

Basal Area and Tree Size

The hardwood stands attained basal areas of 133 square feet per acre (2-inch class and larger), except for the Williams Tract (Table 2). The softwood stands ranged from 187 to 233 square feet per acre.

In the hardwood stands, sugar maple, yellow birch, or white ash were found up to 36 inches d.b.h. In the softwood stands, hemlock was found up to 32 inches d.b.h., but spruce only to 22 inches d.b.h.

Diameter Distribution

Diameter distributions of commercial species for all five stands followed the reverse J-shaped form (Figs. 1–5). Quotients ("q") between tree numbers in successively smaller 2-inch d.b.h. classes varied from 1.34 to 1.44 in hardwoods and 1.50 and 1.56 in softwood stands.[1] However, all the hardwood stands showed bumps or dips in the central part of the diameter distribution, a shape reminiscent of the rotated sigmoid form described by Goff and West (1975). Both softwood stands showed an abrupt decline in slope at about 12 inches d.b.h.

Another expression of diameter distribution is basal area by size groups (Table 3). Although amounts of basal area by size class varied between hardwood and softwood stands, all stands had 60 to 70 percent of the total basal area in the 12-inch d.b.h. class and larger, and about 7 to 9 percent in the 2- to 4-inch d.b.h. classes.

[1] "q" was determined by fitting a linear regression to the logarithm of number of trees over dbh class (Leak 1963). The antilog of b, squared, equals "q." The regression was fitted from the 6-inch class to the largest diameter class that contained at least 1.0 tree per acre. The dashed lines in Figs. 1–5 represent the calculated "q" and the actual stand basal area within the limits of the regression.

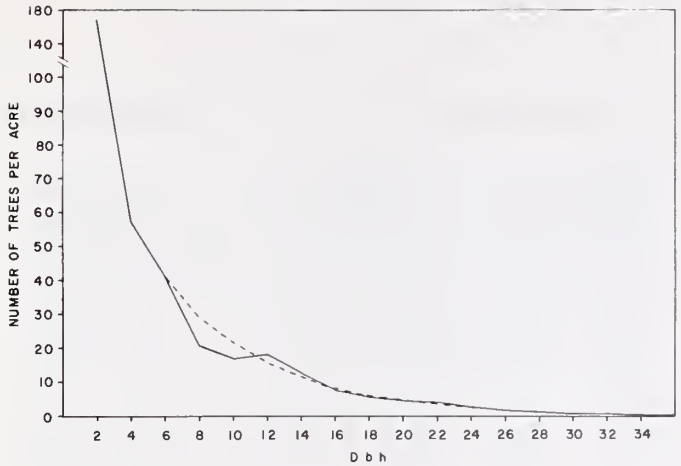

Figure 1.—Number of trees per acre over 2-inch d.b.h. class for the Bowl. Dashed line represents q = 1.36.

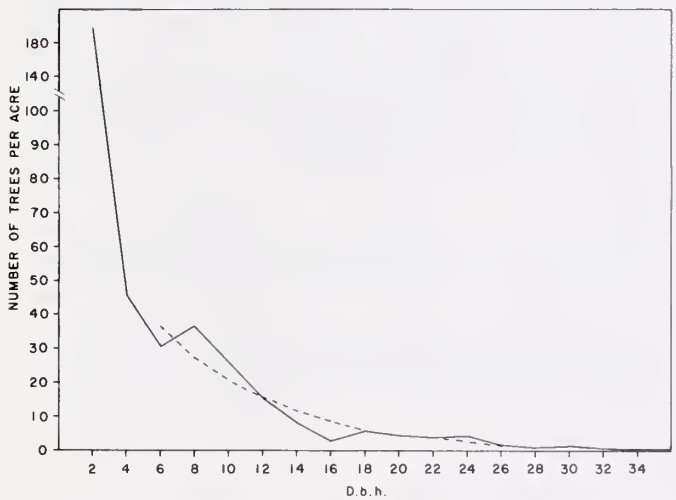

Figure 2.—Number of trees per acre over 2-inch d.b.h. class for Mountain Pond North. Dashed line represents q = 1.34.

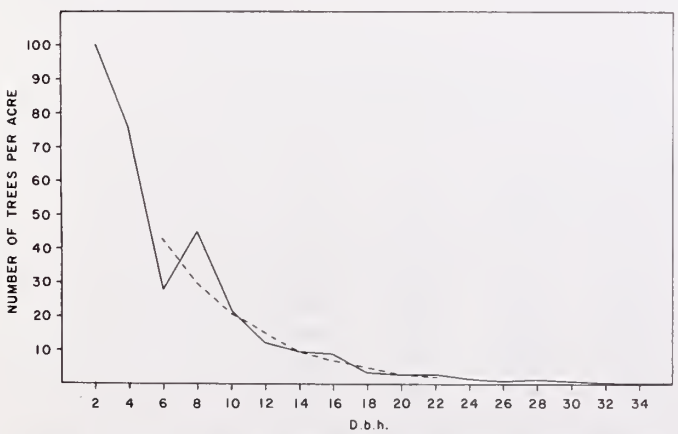

Figure 3.—Number of trees per acre over 2-inch d.b.h. class for the Williams Tract. Dashed line represents q = 1.44.

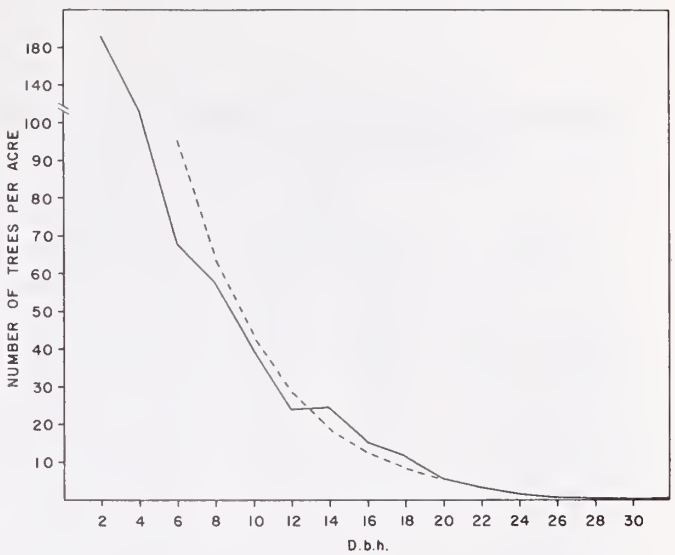

Figure 4.—Number of trees per acre over 2-inch d.b.h. class for Bartlett Ridge. Dashed line represents q = 1.50.

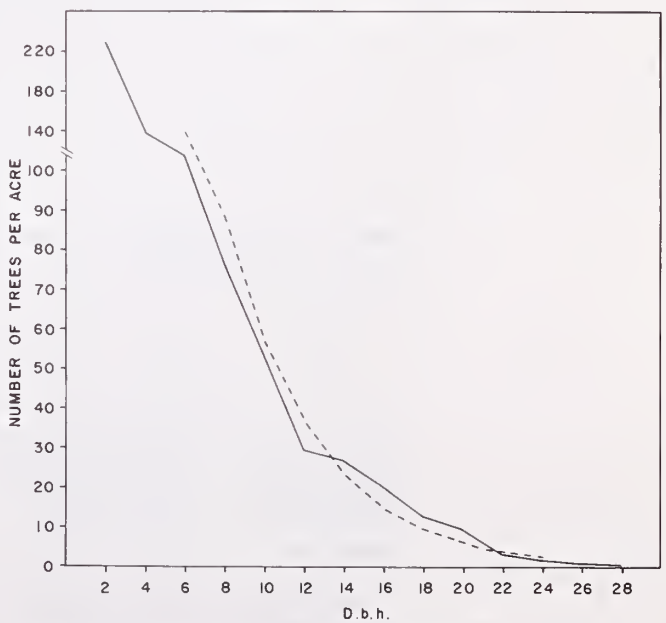

Figure 5.—Number of trees per acre over 2-inch d.b.h. class for Bartlett 19. Dashed line represents q = 1.56.

Table 2.—Basal area per acre (ft^2, 2-inch class plus) and maximum d.b.h. (inches) by species and study area

Species	Bowl		Mt. Pond North		Williams Tract		Bartlett Ridge		Bartlett 19	
	Basal area	Maximum d.b.h.	Basal area	Maximum d.b.h.	Basal area	Maximum d.b.h.	Basal area	Maximum d.b.h.	Basal area	Maximum d.b.h.
Beech	45.0	24	36.4	26	25.2	28	19.7	24	3.6	20
Yellow birch	33.5	36	10.0	30	14.8	32	6.7	16	15.7	14
Sugar maple	46.1	34	69.0	36	28.2	36	—	—	—	—
Red maple	.4	14	1.0	8	29.2	28	10.3	20	45.0	24
White ash	—	—	5.3	36	3.5	20	—	—	—	—
Red spruce	1.7	24	1.3	14	—	—	29.4	22	25.7	22
Eastern hemlock	.4	26	—	—	3.8	16	111.7	32	140.0	26
Paper birch	—	—	—	—	—	—	6.7	14	.7	8
White pine	—	—	—	—	—	—	—	—	2.1	28
Basswood	—	—	5.3	26	—	—	—	—	—	—
Striped maple	6.0	10	3.7	10	2.0	8	.5	2	—	—
Red oak	—	—	—	—	—	—	1.7	20	—	—
Hophornbeam	—	—	1.3	8	—	—	—	—	—	—
Black cherry	—	—	—	—	3.5	16	—	—	—	—
All	133.1		133.3		110.2		186.7		232.8	

Table 3.—Basal area per acre (ft^2) by d.b.h. size group (inches) and study area

Area	D.b.h. size group					
	2–4	6–10	12–14	16–24	26+	A
Bowl	8.6 (1.4)	24.7 (4.6)	27.7	51.9	14.2	133.1
Mt. Pond North	8.4 (2.3)	32.6 (2.7)	20.7	47.3	19.3	133.3
Williams Tract	8.7 (1.0)	33.0 (1.0)	19.5	34.5	12.5	110.2
Bartlett Ridge	13.9 (0.6)	55.0	45.0	68.9	3.3	186.7
Bartlett 19	17.1	77.1	51.4	83.6	3.6	232.8

[a] Basal area of noncommercial species (striped maple, hophornbeam) in parentheses.

Conclusions

The results provide general guidelines on how to recognize stands that are nearing the old-growth or climax condition. Climax hardwood stands contain about 130 square feet of basal area per acre (2-inch class and larger), trees up to 36 inches d.b.h., and 65 to 70 percent or more of the basal area in tolerant hardwood species. The diameter distributions are roughly reverse J-shaped or sigmoid, and the calcuated "q's" are low—1.3 to 1.4. It is quite possible, however, that climax hardwood stands on poorer sites (sandy soils e.g.) would support smaller maximum-size trees and higher "q's" than the stands on fine till described here.

Climax spruce-hemlock stands (before decadence and mortality became widespread) contain 180 to 200 square feet basal area or more. About 70 percent or more of the basal area is tolerant softwoods, with hemlock up to 32 inches and spruce to 22 inches d.b.h. Diameter distributions are reverse J-shaped or sigmoid, sometimes with an abrupt slope change, and calculated "q's" are 1.5 to 1.6.

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Northeastern Forest Experiment Station.
370 Reed Road, Broomall, PA 19008
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